

POLISHING SHEET AND METHOD OF MAKING THE POLISHING SHEET

INTRODUCTION

[0001] Polishing sheets comprising abrasive particles embedded in a fiber-stabilized flexible polymeric material have a high demand in various technical fields. One typical polymeric material which is formed during the process of making polishing sheets are cross-linked polyurethanes. There exists a need to further improve the manufacturing process of polyurethane-based polishing sheets in order to comply with enhanced safety standards and regulations while keeping at least the same product quality, being cost-efficient, and to further enhance the performance and life-time of the polishing sheets.

DETAILED DESCRIPTION

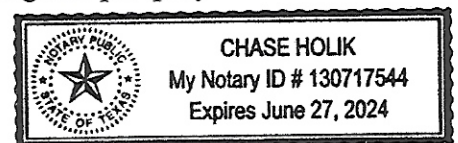
[0002] The present publication is directed to a method of making a polishing sheet comprising cross-linking an organic pre-polymer compound with one or more organic diamine compounds. The one or more organic diamine compounds are herein also called “cross-linking agents.”

[0003] The one or more organic diamine compounds can include, for example, ethylenediamine (EDA), diethylenetriamine (DETA), triethylenetetramine (TETA), tetraethylenepentamine (TEPA), pentaethylenhexamine (PEHA), diethylenediamine (DEDA), or 4,4'-methylene-bis(diethylaniline) (MDEA) .

[0004] As used herein, if not indicated otherwise, the term “organic prepolymer” relates to a prepolymer having a molecular weight of at least 1000 g/mol and contains at least two isocyanate groups.

[0005] It has been observed that certain diamine compounds or combinations of diamine compounds can be very effective for curing of the organic prepolymers, leading to surface treating articles with desirable properties for polishing operations. In aspects, certain combinations of diamine compounds can replace well-known commercial cross-linking agents, for example, Ancamine DL, without causing a decrease in the polishing performance of the obtained product and by complying with enhances safety standards.

[0006] In a certain embodiment, the method of forming the surface treating article of the present disclosure can comprise: forming a reaction mixture including an organic pre-polymer and the



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cross-linking agents ; at least partially coating a fiber web within the reaction mixture; and curing the coated fiber web.

[0007] In a certain embodiment, the reaction mixture can comprise the organic prepolymer, one or more diamine compounds, abrasive particles, and a solvent.

[0008] In one aspect, the organic prepolymer can have an isocyanate functionality of at least 2, or at 3, or at least 4, or at least 5, or at least 6. In another aspect, the isocyanate functionality may be not greater than 10, or not greater than 9, or not greater than 8.6. The isocyanate functionality can be a value within any of the above-noted numbers, such as from 2 to 10, or from 2.5 to 9, or from 3 to 8.6, or from 2 to 4.

[0009] In another aspect, the molecular weight of the organic prepolymer can be at least 1000 g/mol, or at least 2000 g/mol, or at least 5000 g/mol, or at least 8000 g/mol, or at least 10,000 g/mol, or at least 15,000 g/mol. In a further aspect, the molecular weight of the organic prepolymer may be not greater than 25,000 g/mol, or not greater than 20,000 g/mol, or not greater than 18,000 g/mol, or not greater than 15,000 g/mol, or not greater than 10,000 g/mol/

[0010] The organic prepolymer can comprise aromatic rings containing one or more isocyanate groups. In a certain aspect, the organic prepolymer can be a blocked isocyanate-group containing prepolymer. Blocking the isocyanate groups can have the advantage of easier storage, also in the presence of moisture of vulcanizing agents. The blockage of the isocyanate groups can be removed, herein also called “dis-blocked”, for example, by heating. In certain aspects heating for unblocking the isocyanate groups can be conducted at a temperature of at least 100°C, or at least 125°C, or at least 150°C, or at least 200°C, or at least 250°C, or at least 300°C, or at least 350°C. Suitable non-limiting examples of commercially available isocyanate-blocked organic prepolymers can be BL40 or BLM 500, known under the trademark Adiprene(R).

[0011] The reaction mixture can further include a polyol. Non-limiting examples of polyols can be polypropylene glycol, polyethylene glycol, polytetramethylene ether glycol, glycerol, neopentyl glycol, 1,2-pentane diol, pentaerythritol adducts, 1,6-hexane diol, 1,3-butylene glycol, or resin-polyols.

[0012] The reaction mixture can further include additives, such as solvents; plasticizers; chain transfer agents; catalysts; anti-static agents, such as graphite, carbon black, and the like; suspending agents, such as fumed silica; anti-loading agents, such as metal stearate, including lithium, zinc, calcium, or magnesium stearate; lubricants such as wax; wetting agents; dyes; fillers, such as calcium carbonate, talc, clay and the like; viscosity modifiers; defoamers; or any combination thereof.

[0013] The material of the abrasive particles of the surface treating article can be selected from aluminum oxide, silicon carbide, boron carbide, boron nitride, diamond, or any combination thereof. In a further aspect, the abrasive particles can be in form of agglomerated grain. As used herein, the term “agglomerated grain” refers to three-dimensional granules comprising abrasive grain and a binding material, the granules having at least 35 volume % porosity. Unless filamentary grains are described as making up all or part of the grain in the granules, the agglomerated abrasive grain granules consist of blocky or sphere-shaped abrasive grain having an aspect ratio of about 1.0. The agglomerated abrasive grain granules are exemplified by the agglomerates described in U.S. Pat. No. 6,679,758 B2, titled Porous Abrasive Articles with Agglomerated Abrasives, issued to Bright et al. on Jan. 20, 2004, which is incorporated by reference herein in its entirety.

[0014] In one embodiment, the abrasive particles can be distributed homogeneously in the non-woven web. In another embodiment, the abrasive particles can be applied to one side of the non-woven web and therefore, be more concentrated on such a side. In another embodiment, the abrasive particles can be applied to one side of the non-woven web and subsequently applied to the opposite surface of the non-woven web, wherein a higher concentration of particles is on the surfaces rather than the center of the web.

[0015] The abrasive particles can have an average grain size ranging from about 24 grit to about 150 grit according to the U.S. Coated Abrasive Manufacturers Institute (“CAMI”) grading system. In another embodiment, the abrasive particles can have an average grain size from about 30 grit to about 120 grit. In yet another embodiment, the abrasive particles can have an average grain size from about 36 grit to about 100 grit.

[0016] The abrasive particles can have an average particle size (D50) of at least about 50 microns, or at least about 70 microns, or at least about 100 microns, or at least about 150

microns. In yet another embodiment, the abrasive particles may have an average particle size not greater than about 750 microns, not greater than about 700 microns, or not greater than about 600 microns. The abrasive particles can have a Mohs hardness of at least about 8.0, such as at least about 8.5, even at least about 9.0.

[0017] In a further aspect, the amount of the abrasive particles can be at least 5 wt% based on the total weight of the surface treating article, or at least 10 wt%, or at least 15 wt%, or at least 20 wt%, or at least 25 wt%, or at least 30 wt%, or at least 35 wt%, or at least 40 wt%. In another aspect, the amount of the abrasive particles may be not greater than 70 wt% based on the total weight of the surface treating article, or not greater than 60 wt%, or not greater than 50 wt%.

[0018] In a further embodiment, the abrasive particles can be surface treated. In one aspect, the abrasive particles can be silylated. In another aspect, the surface treatment can be done by a coupling agent. The coupling agent can be a silane containing coupling agent selected from an aminoalkylsilane, an isocyanatosilane, a chloroalkylsilane, or any combination thereof.

[0019] In one embodiment, the polishing sheet of the present disclosure can be a unified wheel disc formed from a plurality of non-woven abrasive sheets, each sheet comprising a lofty fiber web coated by the reaction mixture. The nonwoven abrasive sheets can be stacked, unitized, and cured under pressure at an elevated temperature. A unified wheel disc can be cut from the slab along with a centered hole for fitting onto the abrasive tool.

[0020] The fiber web can be a woven or a non-woven fiber web, and can be formed by synthetic polymeric fibers or natural fibers. In one embodiment, the natural fiber can be chosen from a kenaf fiber, a hemp fiber, a jute fiber, a flax fiber, a sisal fiber, or any combination thereof. In another embodiment, the synthetic polymeric fibers can be chosen from a polyamide, a polyimide, a polyester, a polypropylene, a polyethylene, or a combination thereof. In another embodiment, the fiber web can be a blend of different fiber types, for example, a blend of different natural fibers, such as a blend of kenaf fibers and flax fibers, or a blend of different synthetic polymeric fibers, such as a blend of polyamide fibers and polyester fibers. In even another aspect, the fiber blend can include a blend of different polyamide fibers.

[0021] In a particular embodiment, the fiber web can be a non-woven fiber web made of a polyamide. In a certain aspect, the polyamide fibers can be selected from nylon fibers or aramid

fibers. Examples of nylon fibers can be nylon-6 or nylon-6,6. A blend of different polyamide fibers can include a blend of nylon-6 and nylon-6,6 fibers.

[0022] Each type of fibers can be present in any portion from about 1 wt % to about 99 wt % based on the total weight of the polishing sheet, such as about 5 wt %, about 10 wt %, about 20 wt %, about 30 wt %, about 40 wt %, about 50 wt %, about 60 wt %, about 70 wt %, about 80 wt %, about 90 wt %, or even about 95 wt %. A blend of two types of staple fibers can have any ratio ranging from about 1:99 to about 50:50, such as about 5:95, about 10:90, about 20:80, about 30:70, or about 40:60. The ratio can be based on the weight of the types of fiber or volume.

[0023] In a further embodiment, the fibers of the fiber web can have a linear density ranging from about 50 deniers to about 1200 deniers. In another embodiment, a blend of fibers can include one portion of staple fibers having a linear density between of at least about 50 deniers, such as at least about 60 deniers, at least about 80 deniers, at least about 100 deniers, at least about 200 deniers, at least about 250 deniers, at least about 300 deniers, at least about 320 deniers, at least about 350 deniers, or at least about 400 deniers. In another embodiment, the blend of fibers includes one portion of staple fibers having a linear density not greater than about 250 deniers, such as not greater than about 280 deniers, not greater than about 300 deniers, not greater than about 400 deniers, not greater than about 500 deniers, not greater than about 600 deniers, not greater than about 800 deniers, not greater than about 900 deniers, not greater than about 1000 deniers, or not greater than about 1200 deniers. As used herein, a denier is the mass in grams per 9,000 meters length of a single filament. For example, a nylon fiber having 200 deniers means that 9,000 meters of this fiber weighs 200 grams.

[0024] In a particular aspect of the method, forming the polishing sheet can comprise forming a plurality of fiber webs coated with the reaction mixture, assembling the coated fiber webs to a stack of coated fiber webs, and curing the stack of coated fiber webs. In one aspect, the coating may be conducted by subjecting the fiber-web to a dip and squeeze process with the respective reaction mixture.

[0025] In a certain embodiment, the density of the polishing sheet can be adjusted by the amount of coated fiber webs assembled to the fiber web stack, and applying pressure to reach a desired thickness of the polishing sheet. Technical details of embodiments of forming the polishing

sheet can be found, for example, in US 9,840,648 and US 10,022,841, which contents are expressly incorporated by reference herein.

[0026] As further shown in the Examples, it has been surprisingly found that certain diamine compounds or combinations of diamine compounds can be very suitable as cross-linking agent for curing a urethane prepolymer. In certain embodiments, it is possible to replace with the diamine compound(s) the commercially known cross-linking agent Ancamine DL without loss of the polishing efficiency or life time, and which allows making the manufacturing process better suitable for enhanced industrial safety standards.

[0027] **Examples**

[0028] Reaction mixtures were prepared by combining a blocked urethane prepolymer in an amount from 20 to 35 wt%, abrasive particles in an amount of 40 to 50 wt%, one or more diamine compounds as cross-linking agent in an amount of 0.5 to 7 wt%, and an organic solvent in an amount of 15 to 25 wt%. The weight percent ratio between the cross-linking agent and the urethane prepolymer was between 1:5 and 1:15. The slurries were prepared that a viscosity of the slurries was between 2000 and 3000 cps at 25°C.

[0029] Other optional ingredients in amounts of up to 10 wt% can be a phenoxy resin, sheet silicate (talc), lithium stearate, a shear thinning agent, an antioxidant, or any combination thereof.

[0030] The aim of the experiments was to evaluate cross-linking agents with regard to their suitability to replace commercial cross-linking agents, for example, Ancamine DL50, for crosslinking urethane prepolymers.

[0031] The following diamine compounds have been tested in varying combinations and concentration ratios: ethylenediamine (EDA), diethylenetriamine (DETA), triethylenetetramine (TETA), tetraethylenepentamine (TEPA), pentaethylenehexamine (PEHA), diethylenediamine (DEDA), or 4,4'-methylene-bis(diethylaniline) (MDEA). As comparative cross-linking agent was used Ancamine DL50.

[0032] Furthermore, as representative abrasive particles were used in the experiments silicon carbide particles having a particle size of 30 to 500 microns, and aluminum oxide particles (brown alumina particles, ANSI 280) having an average particle size of 30 to 500 microns.

[0033] As polyurethane prepolymer was used BLM500 (from Lanxess) and BL-40 (from Lanxess).

[0034] The solvent used in the experiments was methyl isobutyl ketone (MIBK).

[0035] With the above-described reaction mixtures (herein also called abrasive slurries), coated fiber webs were prepared by coating a non-woven fiber webs of nylon 6.6 fibers via a dip and squeeze process with the respective reaction mixture. The coated fiber webs were stacked on top of each other to a stack of coated fiber webs and positioned between two metal plates, wherein the number of coated fiber webs was determined by the final desired disc density, for example, 2 g/cm³ with a thickness of 0.5 inches, or 3 g/cm³ with a thickness of 0.5 inches. The stack of fiber webs was cured in an oven at a temperature ramp between 99 and 140°C. For further details regarding the manufacturing of the polishing sheets (also called polishing discs) see also US 9,840,648 and US 10,022,841.

[0036] Table 1 provides a summary of the tested cross-linking agents:

[0037] Table 1:

Sample	Type of cross-linking agent	Curative Ratio of Cross-linkers
S1	EDA	100
S2	EDA / TETA	25 / 75
S3	EDA / TETA	50 / 50
S4	EDA / TETA	75 / 25
S5	EDA / DETA	25 / 75
S6	EDA / DETA	50 / 50
S7	EDA / DETA	75 / 25
S8	EDA / MDEA	25 / 75
S9	EDA / MDEA	50 / 50
S10	EDA / MDEA	75 / 25
S11	DETA	100
S12	DETA / MDEA	25 / 75
S13	DETA / MDEA	50 / 50

S14	DETA / MDEA	75 / 25
S15	DETA / TETA	25 / 75
S16	DETA / TETA	50 / 50
S17	DETA / TETA	75 / 25
S18	TEPA	100
S20	TEPA / DEA	25 / 75
S21	TEPA / DEA	50 / 50
S22	TEPA / DEA	75 / 25
S23	TEPA / DETA	25 / 75
S24	TEPA / DETA	50 / 50
S25	TEPA / DETA	75 / 25
S26	TEPA / MDEA	25 / 75
S27	TEPA / MDEA	50 / 50
S28	TEPA / MDEA	75 / 25
S29	DEDA	100
S30	DEDA / DEA	25 / 75
S31	DEDA / DEA	50 / 50
S32	DEDA / DEA	75 / 25
S33	DEDA / DETA	25 / 75
S34	DEDA / DETA	50 / 50
S35	DEDA / DETA	75 / 25
S36	DEDA / MDEA	25 / 75
S37	DEDA / MDEA	50 / 50
S38	DEDA / MDEA	75 / 25
S39	TEPA	100
S40	TEPA / EDA	25 / 75
S41	TEPA / EDA	50 / 50
S42	TEPA / EDA	75 / 25
S43	TEPA / DETA	25 / 75
S44	TEPA / DETA	50 / 50

S45	TEPA / DETA	75 / 25
S46	TEPA / MDEA	25 / 75
S47	TEPA / MDEA	50 / 50
S48	TEPA / MDEA	75 / 25

[0038] The obtained polishing discs were evaluated with regard to their polishing performance. It could be shown that certain combinations of the above-described diamines as cross-linking agents can lead to polishing discs having the same or an even enhanced polishing performance in comparison to commercial cross-linking agents, for example, Ancamine DL 50.